DOCKET NO. 1293.1132/MDS/JGM

TITLE OF THE INVENTION

PHASE CHANGE OPTICAL DISC

J.B. 2-12-01

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Application No. 99-29278, filed July 20, 1999, in the Korean Industrial Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a phase change optical disc, the phase control layer of which has an optical characteristic varying with laser beam irradiation, and more particularly, to a phase change optical disc, the resolving power of which is improved to allow high density optical recording, even if the size of a recording mark is reduced as the density of the optical disc increases.

2. Description of the Related Art

Phase change optical discs are optical information recording media on which information can be written, and from which information can be reproduced and erased by irradiation with laser beams. For phase change optical discs, an optical head can easily be constructed, and simultaneous recording and removal (i.e., overwriting) can be easily

performed. For this reason, there has been research and investigation into increasing the density of a phase change optical disc.

FIG. 1 is a vertical cross sectional view of a typical phase change optical disc. Referring to FIG. 1, a conventional phase change optical disc 10 has a multilayer structure in which a first dielectric layer 12, a phase change recording layer 13, which is formed of a phase change material whose optical characteristic varies with irradiation of a recording beam, a second dielectric layer 14 and reflective layer 15, are sequentially laminated on a transparent substrate 11, which is formed of, for example, acrylic acid resin or polycarbonate (PC).

In this multilayer structure, the first and second dielectric layers 12 and 14 are typically formed of $ZnS\text{-}SiO_2$. The phase change recording layer 13 is formed of $Ge_2Sb_2Te_5$. The reflective layer 15 is formed of aluminum (Al) or an aluminum alloy.

Information is recorded on or reproduced from this conventional phase change optical disc 10 having a multilayer structure. This is based on its characteristic that a part of the phase change recording layer 13, on which a laser beam is applied, becomes a crystalline or amorphous state depending on the power of the incident laser beam and the cooling speed, and thus the optical characteristic of the phase change recording layer 13 is changed. Information is recorded by generating a recording mark by melting the phase change recording layer 13, which is initialized to a crystal phase by laser beam irradiation, using a recording pulse of high power and then rapidly cooling it into an amorphous state. Since the reflectance at the crystal phase change recording layer 13 when a laser beam is incident on the optical disc is different from that at the amorphous phase change recording layer 13 when a laser beam is incident on the optical disc, the information of a recording mark is reproduced as an electrical signal by a

photodetector, which detects the difference between the reflectances. On the other hand, information is erased by removing a recording mark by crystalizing the amorphous recording mark using an erasing pulse of low power.

In such a phase change optical disc, the size of a recording mark becomes smaller as the recording density increases. Where the size of a recording mark becomes smaller, cross-talk occurs between adjacent marks during reproduction of a signal, thus deteriorating the characteristics of the reproduced signal. Moreover, the resolving power for reproducing the signal becomes poor.

The resolving power for reproducing the signal of a phase change optical disc depends on the wavelength (λ) of a laser beam and numerical aperture (N.A.) of an object lens in an optical system. The characteristic of the reproduced signal is bad when the length of a recording mark (or a pit) formed on an optical disc is smaller than the value of $\lambda/(2\ \text{N.A.})$, indicating a diffraction limit. The characteristic of the reproduced signal is good when the length of a recording mark (or a pit) formed on an optical disc is greater than the value of $\lambda/(2\ \text{N.A.})$, indicating a diffraction limit. Accordingly, it is required to decrease the wavelength of a laser beam and to increase the numerical aperture of an objective lens for the purpose of recording information on a phase change optical disc at a high density.

However, there is a limit in decreasing the wavelength of a laser beam and in increasing the numerical aperture of an object lens. Particularly, a lens having little optical aberration is required to increase the numerical aperture of an object lens, but it is difficult to manufacture such a lens practically. Moreover, the lens having little optical aberration may cause skew in a disc and vibration, spoiling the stability of focus.

Accordingly, what is desired is a high resolution reproduction method for reproducing a signal of good quality by eliminating the signal of an adjacent mark, which is mixed into the signal of a pertinent mark, thereby realizing high density in a phase change optical disc.

SUMMARY OF THE INVENTION

To solve the above problem, an object of the present invention is to provide a high density phase change optical disc for obtaining a playback signal of good quality by eliminating the signal of an adjacent mark, which is mixed into the signal of a pertinent mark when optical information is reproduced from the optical recording medium, even if the size of a recording mark is reduced for realizing a high density optical medium.

Additional objects and advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

To achieve the above object of the invention, there is provided a phase change optical disc including at least one first dielectric layer thinly formed on a transparent substrate; a phase change recording layer which converts between a crystal phase and an amorphous phase by irradiation with a recording beam; a reflective layer; and a phase control layer disposed between the substrate and the phase change recording layer, the phase control layer having two areas in which the irradiation with a reproduction beam causes a phase difference that alters the optical path of the reflected reproduction beam passing through the areas, the two areas being defined in a laser spot.

In a preferred embodiment of a phase change optical disc according to the present invention, on the transparent substrate are sequentially laminated the first dielectric layer, the phase control layer having two areas in which the irradiation with a reproduction beam causes a phase difference that alters the optical path of the reflected reproduction beam passing through the areas, the two areas being defined in a laser spot, a second dielectric layer, the phase change recording layer, which converts between a crystal phase and an amorphous phase by irradiation with a recording beam, a third dielectric layer, the reflective layer, and a protective layer.

It is preferable that the phase difference of the reflected reproducing beam caused by irradiation of the phase control layer substantially has a minimum value of 0 degrees in one of the two areas defined on the phase control layer, and a maximum value of 180 degrees in the other area. The phase control layer is formed of a phase change material which converts between a crystal phase and an amorphous phase or converts from a crystal phase of one structure to a crystal phase of another structure. Preferably, the phase control layer is formed of a material selected among the GeSbTe family, InSbTe family, AgInSb family, Au, and Ni.

BRIEF DESCRIPTION OF THE DRAWINGS

The above object and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a schematic vertical sectional view of a conventional phase change optical disc;

FIG. 2 is a schematic vertical sectional view of a phase change optical disc according to an embodiment of the present invention;

FIG. 3 is a schematic vertical sectional view of a phase change optical disc according to another embodiment of the present invention; and

FIG. 4 is a diagram illustrating the distribution of intensity of an optical spot and the distribution of temperature on an optical disc to explain the effects of a phase change optical disc according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

Referring to FIG. 2, a phase change optical disc 20 according to an embodiment of the present invention has a multilayer structure in which a first dielectric layer 22, a phase control layer 23, a second dielectric layer 24, a phase change recording layer 25, a third dielectric layer 26, a reflective layer 27 and a protective layer 29 are sequentially laminated on a transparent substrate 21, which is formed of, for example, a transparent acrylic acid resin material or a polycarbonate material.

Alternatively, as another embodiment of the present invention, an optical disc 20a, as shown in FIG. 3, further includes a fourth dielectric layer 28 between the reflective layer 27 and the protective layer 29 in the multilayer structure shown in FIG. 2.

According to the present invention, the phase control layer 23 has a distribution of temperature as shown in FIG. 4 when a reproduction beam of high power is applied thereon. According to this distribution of temperature, the phase control layer 23 can be divided into a low temperature area and a high temperature area on the basis of a transition point TP. Since refractivity varies with the temperature, a different phase difference for light passing through the phase control layer 23 occurs in each area. In each area, the phase difference is between the reflected reproduction beam incident to the area, and the refracted reflected reproduction beam passing through the area. In other words, the high temperature area becomes a mask area, and the low temperature area becomes an aperture area.

In the mask area, the reflectance of a recording mark is the same as that of the peripheral space, and the phase difference is 0 degrees. Therefore, within the mask area, essentially none of the reproduction beam incident to the phase change recording layer is reflected through the mask area. In the aperture area, the reflectance of a recording mark is the same as that of the peripheral space, and the phase difference is 180 degrees. Therefore, in the aperture area, the reproduction beam incident to the phase change recording layer is maximally reflected through the aperture area.

As described above, a phase difference for light passing through the phase control layer occurs in two areas due to irradiation, and thus two areas in which the optical path of the reproduction beam changes are defined in a laser spot. The phase difference substantially has a minimum value of 0 degrees in one of the two areas, and a maximum value of 180 degrees in the other area.

The phase control layer 23 is formed of phase change material, such as a compound from the GeSbTe family, InSbTe family, AgInSbTe family, Au, or Ni. The phase change material reversibly converts between a crystal phase and an amorphous phase, or converts from a crystal phase of one structure to a crystal phase of another structure by irradiation with a reproducing beam.

The phase change recording layer 25 is formed of material, such as a compound from the GeSbTe family, the InSbTe family, or the AgInSbTe family. This material reversibly converts between a crystal phase and an amorphous phase by irradiation with a recording beam.

The first through third dielectric layers 22, 24 and 26 are usually formed of a material having a low refractivity to correlatively control the light absorptances and reflectances of the crystalline and amorphous phases of the phase change recording layer 25. Preferably, each of these layers 22, 24 and 26 may be formed of Al_2O_3, ZnS-SiO_2, Si_3N_4, SiO_2, MgF_2, NaF_2, LiF_2, CaF_2, or AlF_2.

The reflective layer 27 is formed of metal of excellent quality, for example, Al, a compound from the Al-Ti family, Cu, Au or an alloy thereof.

According to a phase change optical disc 20 and 20a of the present invention having a multilayer structure as described above, information is recorded by generating a recording mark. The recording mark is created by melting the phase change recording layer 25, which is initialized to a crystal phase by laser beam irradiation, using a recording pulse of high power, and then cooling it into an amorphous state.

During reproduction of information, the refractivity of the phase control layer 23 changes due to an increase in temperature, which results from the irradiation with a reproduction beam. The refractivity creates a phase difference, thus changing the optical path of the reproduction beam reflected from the phase change recording layer 25. As a result, two local areas are defined within the spot LS of the reproduction beam where the phase difference occurs, as shown in FIG. 4. In other words, a mask area M and an aperture area A are defined, and the phase difference of a reflected reproduction beam in each area makes it possible to reproduce the information of the recording mark (or pit).

The recording mark P in the mask area M has the same reflectance as a peripheral space and has a phase difference of 0 degrees, thereby making a mask effect. However, while it is ideal that the amount of reflected reproduction beam passing through the mask area M is 0, in actuality, a little amount of reflected reproduction beam does pass through the mask area M.

The recording mark P in the aperture area A has the same reflectance as a peripheral space and has a phase difference of 180 degrees. Thus the amount of the incident reproduction beam which is reflected becomes maximum. Accordingly, the signal of the reflected beam from the aperture area A is read, and thus only the information of the recording mark P in the aperture area A is read, thereby implementing reproduction. This makes it possible to use the reflected beam from only the partial spot area (i.e., aperture area) of a reproduction beam so that the size of the effective spot of a reproduction beam can be reduced.

As described above, according to a phase change optical disc, a phase difference with respect to a reflected reproduction beam occurs in the mask area and the aperture area within a

laser spot on a phase control layer when a reproduction beam is incident, and the information of a recording mark can be reproduced due to the phase difference. Therefore, the size of the effective spot of a reproduction beam can be reduced. Accordingly, the mixing of the signals between the adjacent marks or the adjacent tracks is decreased, and influence of cross-talk is also decreased, thereby realizing a high density optical disc and improving the resolution power of a reproduction signal.

Although a few preferred embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.